6.5 Wave Interaction

Student Resources:
Student Edition pages 72–73
Science Notebook 6.5A–B

Connect | **Construct** | Investigate | Extend | Assess

Materials
- Clear drinking glass, water (*Introduction*)
- Handheld mirrors, at least 15 cm × 15 cm (6 in. × 6 in.), red and green markers (Science Notebook 6.5A)
- Masking tape or cones, 1 pair of binoculars (Science Notebook 6.5B)

Vocabulary
refract (ri·'frakt) to bend light or sound waves as they pass through different mediums
reflect (ri·'flekt) to bounce energy off an object
convex lens ('kän·veks 'lenz) a lens that focuses light
concave lens (kän·'kāv 'lenz) a lens that causes light to spread out

Supplemental Materials
BLM 6.5A
BLM 6.5B
TM-6.5A

Preparation

Obtain a glass and container of water. (*Introduction*)

Prepare a workstation for each pair of students. Have students bring mirrors from home if possible. See **BLM 6.5A Instructions: Reflection Exercise** for information. Print **BLM 6.5B Tracing Pattern** for each student. (Science Notebook 6.5A)

Use masking tape or cones to mark out a course for students to walk. (Science Notebook 6.5B)

Objective
Students will analyze and describe how light and sound interact with matter, such as mirrors, lenses, and rough surfaces.

Content
Light and sound waves are affected by the characteristics of the matter through which they pass. An object that light passes through is transparent. In some cases, the object will cause the wave to bend, or refract. For example, water refracts light, causing an object to look different underwater than above water. An object that light passes through but produces a blurred image is translucent; an object that prohibits light from passing through is opaque. An opaque object stops light from passing through by absorbing the light or reflecting it. Darker objects absorb more light than lighter objects, and the rougher an object's surface, the more it will spread out the light it reflects. Sound waves interact with surfaces in a similar way. A porous object absorbs more sound than a dense object. Also, the rougher an object's surface, the more it will spread out the sounds it reflects. In general, an object with a rough surface does not make a good mirror and does not produce good echoes.

A lens is typically made of transparent glass or plastic. A convex lens is thicker in the middle than at the edges. This shape causes the light that passes through it to become focused. A convex lens makes an object appear larger. A concave lens is thicker at the edges than in the middle and spreads out the light that passes through it. A concave lens makes objects appear smaller. Many familiar devices, including microscopes, binoculars, and telescopes, use a combination of lenses and reflecting mirrors to make small objects appear larger or distant objects appear closer.

Introduction
Ask students if they have ever noticed how adding water to a glass makes it look different than when there is only air in the glass. Fill and empty the glass several times to allow students to observe the difference. (**The glass appears shallower with water in it.**) Put a pencil in the glass of water. Ask students to describe the part of the pencil in the water. (**Possible answers: It looks shorter; it looks bigger.**) Explain that water bends the light in a way that makes the pencil look different.

Directed Instruction
Student Edition pages 72–73
Ask volunteers to read the text aloud. Explain that when a medium **refracts** light, it causes the light to bend or change its direction. Prisms refract light. When an object **reflects** light, the light energy bounces off the object. The color of an object also affects how light is either reflected or absorbed. Explain that dark colors absorb more light, which changes to thermal energy. Dark-colored clothing absorbs light and warms a person. Explain that light colors reflect more light, so light-colored clothing keeps a person cooler. Lenses are transparent and refract light. A **convex lens** focuses light. A **concave lens** spreads out light.

Direct students to the images and have them pick out the transparent, translucent, and opaque objects. (**The clouds are translucent; the windows and water are transparent; the people, buildings and windowsills are opaque.**) Direct students to the image of the mirror and read the caption. Direct students to the concave and convex lens diagram. Ask students what is happening to the light rays in the diagram after they pass through the concave lens. (**They are being spread out.**) The convex lens? (**They are being focused.**) Explain that hand lenses use convex lenses. Ask students what happens to the appearance of an object when they look at it through a hand lens. (**It appears to get larger.**) Ask students what would happen to the appearance of an object if they looked at it through a concave lens. (**It appears to get smaller.**)

? (**No, it is very porous and porous objects absorb sound rather than reflect it.**) Direct students to the *Quick Fact* box and read the caption aloud. Explain that the human eye focuses light. Does it function as a concave or a convex lens? (**convex**)

Science Notebook 6.5A–B Reflection and Binocular Walk

Assign pairs of students to different work stations. Read the instructions on Science Notebook 6.5A. Direct students to complete the activity. While students are completing the tracing activity on **BLM 6.5B Tracing Pattern**, take one pair of students at a time to the course prepared for Science Notebook 6.5B. Read the instructions with them and have them complete the activity. While looking through the binoculars the correct way, students will need to look far ahead to see anything in focus. This means they will need to start halfway across the room and look at the start of the course. Then they will walk across to the course while looking at the rest of the course. Rotate students until every pair has completed both activities.

After all pairs have completed both activities, discuss their experiences. Ask them what they found most difficult about tracing the pattern in the reflection, and why. (**Possible answers: In the mirror, a hand appears to be moving in the opposite direction, making the task difficult.**) Display **TM-6.5A Binoculars**, and direct students to the placement of the lenses and prisms in the binoculars. Show them the path that light rays travel through the binoculars to their eyes. Ask students why it was a challenge to walk the course while looking through the binoculars. (**The lenses distorted the distances; looking through the binoculars in the regular way, things appeared closer than they actually were; looking through the binoculars backward, things appeared farther away.**)

Lesson Review

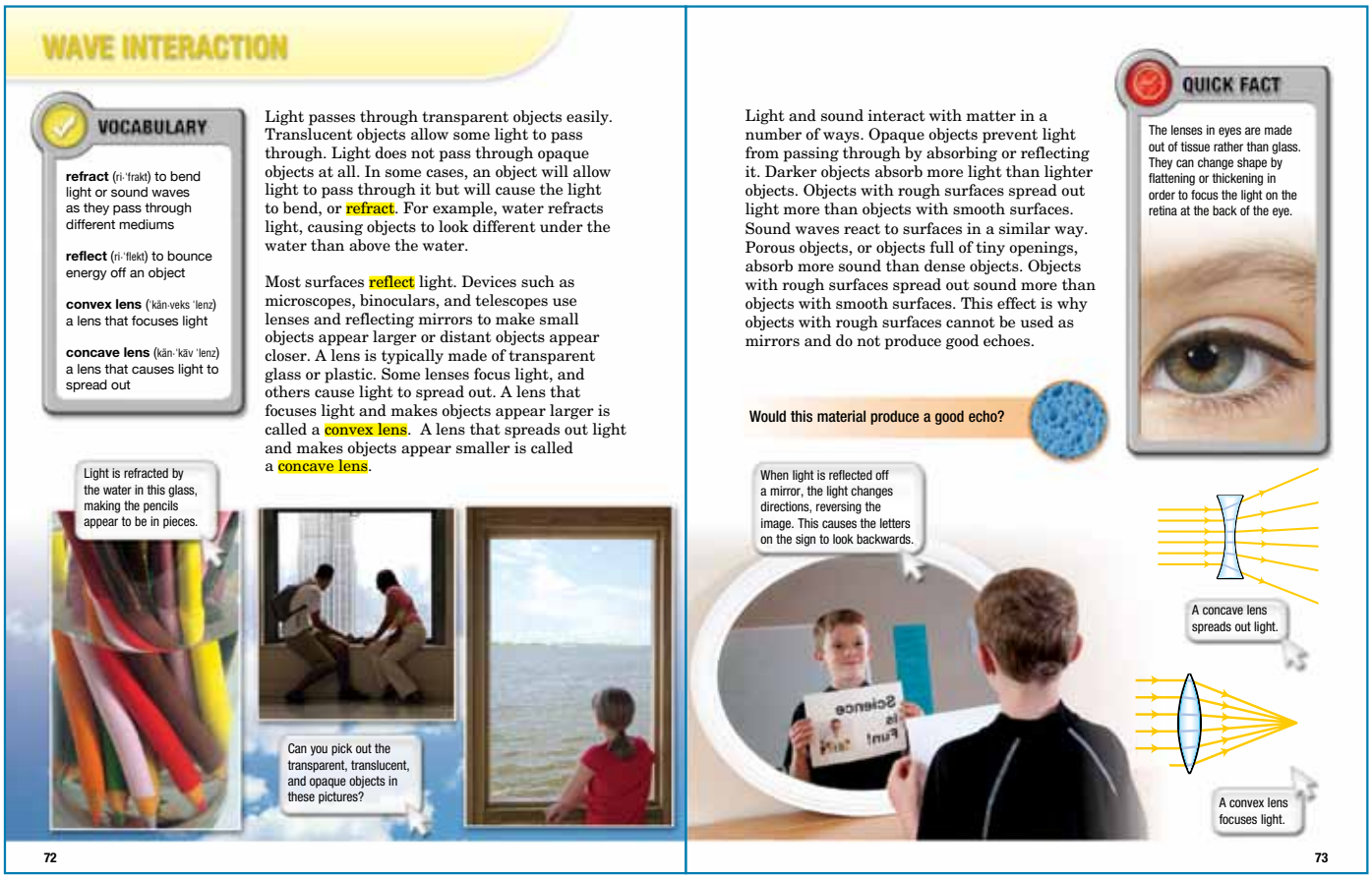
What happens to light as it passes through a prism? (**It gets refracted.**) What does a mirror do to light? (**reflects it**) What happens to the image when it is reflected in a mirror? (**The light changes directions, reversing the image.**) What type of lens should a scientist use to get a close-up view of a tiny organism? (**convex lens**) Which type of object prevents light from passing through? (**opaque**) What type of lens spreads out light? (**concave**) If you wanted to have a room that echoed well, what type of walls would you need? (**smooth, hard**)

Connection

Students often think telescopes are used only for studying space. The telescope has actually had other uses in the past. After it was invented in 1608, it was produced in a collapsible design that began to be used aboard ships. At sea, the telescope went by the more common name of *spyglass*. Although other instruments, such as the compass and sextant, were important for long-distance navigation, mariners relied on the spyglass for scanning the horizon in search of coastlines and enemy ships.

Safety

Caution students to use care when transporting and holding mirrors.



Science Notebook Answer Key: Chapter 6

6.4A Notebook Sunlight

Watch as your teacher demonstrates the use of a prism. Complete the exercises.

1. Show the path of light from the sun to the prism to the paper.

2. List the colors of the visible spectrum, in the correct order, on the diagram above.

3. Which color bent the most? violet

4. Which color bent the least? red

5. Place a thermometer in the colors until the temperature stops changing.

   Record the highest temperature reached. Answers will vary.

6. Place the thermometer above the red region and not in any of the colors.

   Record the highest temperature reached Answers will vary but should be greater than the answers for 5 and 7.

7. Place the thermometer below the violet region and not in any of the colors.

   Record the highest temperature reached. Answers will vary.

8. Describe any differences in the temperatures measured.

   Answers will vary but the temperature recorded for 6 should be greater than the temperatures recorded for 5 and 7.

6.4B Notebook Spectrum Order

The electromagnetic spectrum contains many types of EM radiation, such as radio waves, visible light, gamma rays, ultraviolet rays, infrared waves, and X-rays.

1. Using the electromagnetic spectrum in your book, place each of the above types of EM radiation in order from the longest to the shortest in the Wavelength column.

2. Do the same for the Frequency and Energy columns. Remember that if a wave has a long wavelength, it has a low frequency. Waves with high frequencies carry high amounts of energy.

	Wavelength	Frequency	Energy
longest ↓ shortest	radio	gamma rays	gamma rays
	infrared	X-rays	X-rays
	visible light	ultraviolet	ultraviolet
	ultraviolet	visible light	visible light
	X-rays	infrared	infrared
	gamma rays	radio	radio

3. Which type of EM radiation has the lowest frequency? radio

4. Which type of EM radiation has the highest energy? gamma rays

5. Which type of EM radiation has the shortest wavelength? gamma rays

6. Name three ways in which X-rays are different from radio waves.

   Example: X-rays have shorter wavelength, higher frequency, and higher energy.

6.5A Notebook Reflection

Looking straight at the tracing pattern, place your green marker on Start and trace the line until you get to Finish. Next, look only at the reflection of the tracing pattern in the mirror, not at the paper itself. Place your red marker on Start and trace the line until you get to Finish. Complete the exercises below.

1. Look at the accuracy of your green lines and red lines. Was it harder to trace the pattern while looking straight at it or while looking at its reflection? Explain your answer.

   Example: It was harder to trace the pattern while looking at its reflection because it seemed backward.

2. As you traced the pattern while looking at its reflection, which was more difficult—tracing parts of the line that went to your left and right or tracing parts of the line that went toward and away from you? Explain your answer.

   Example: It was more difficult to trace when moving toward or away from me because my hand appeared to be moving the opposite direction than it was really moving.

3. Explain the difference between reflect and refract.

   Reflect means to bounce light off something; refract means to bend light or sound waves.

4. How is a concave lens different from a convex lens?

   A concave lens is curved inward and spreads light out. A convex lens is curved outward and focuses light.

6.5B Notebook Binocular Walk

Look only through the binoculars as you walk through the course. Your goal is to walk within the lines. Then close one eye and look through the opposite end of the binoculars. Walk the course again. Complete the exercises below.

1. What did you see when you looked through the binoculars the first time? How was this different from what you saw without the binoculars?

   Example: Things were blurry until I looked farther away; faraway things look closer to me than they really are.

2. What was the most difficult thing about walking the course with the binoculars the first time?

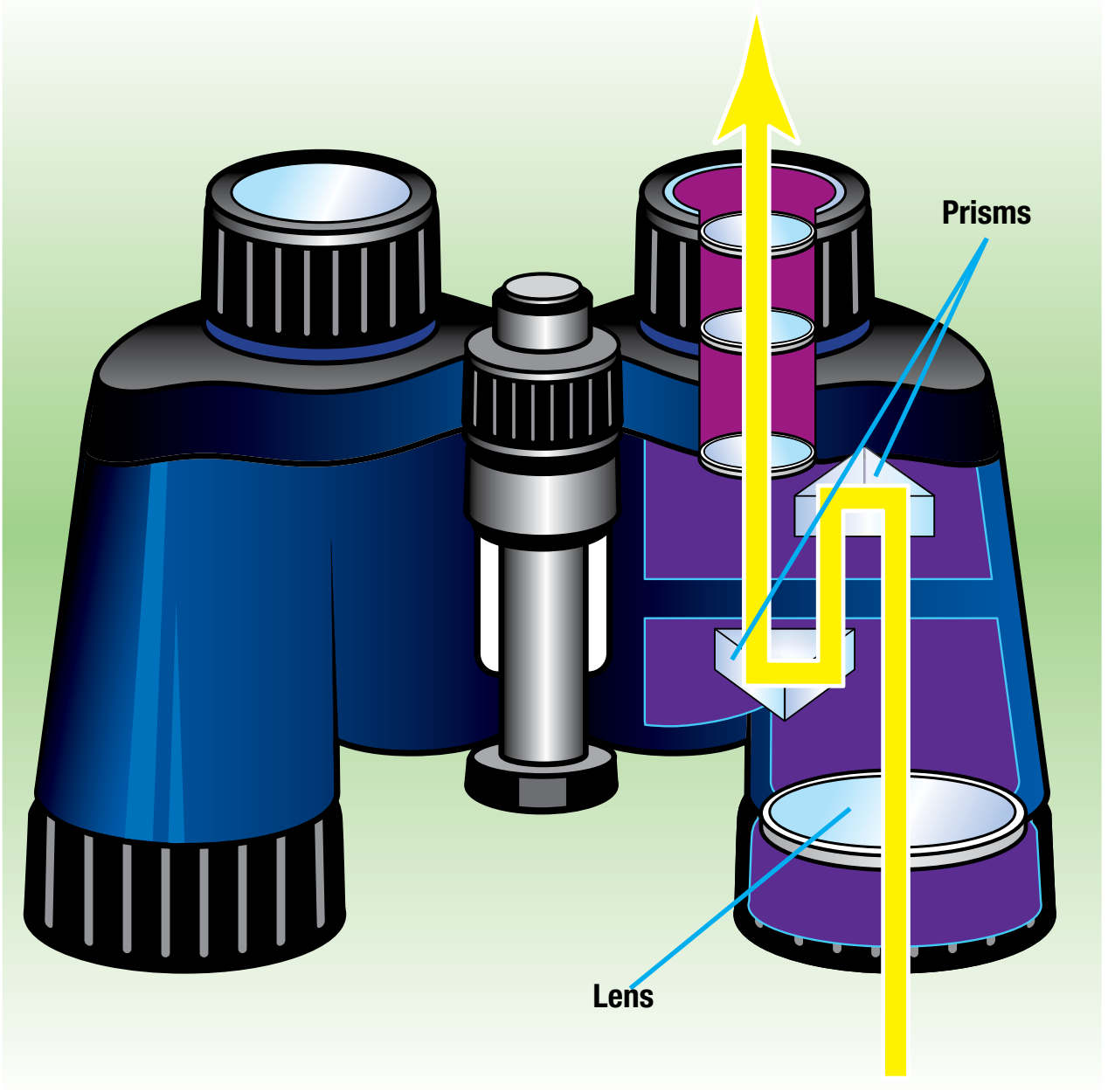
   Example: I could not see because it was out of focus unless I looked far in front of me; then it was hard to remember when to turn.

3. What did you see when you looked through the opposite end of the binoculars?

   Example: Everything looked smaller than it really was.

4. What was the most difficult thing about walking the course and using the opposite end of the binoculars?

   Example: I could not see very far in front of me, so I had to walk very slowly.



Binoculars

TM 6.5A

13.6 Pulse Rate Investigation

Body Systems I

Student Resources:
Science Notebook 13.6A–D

Connect | Construct | **Investigate** | Extend | Assess

Materials
- Stopwatches (Science Notebook 13.6A–B)
- Colored pencils (Science Notebook 13.6C)

Vocabulary

Supplemental Materials

Preparation

Obtain 1 stopwatch for each student pair. Practice taking your radial (wrist) and carotid (neck) pulse rates, so that you can help students who may be struggling to find theirs. (Science Notebook 13.6A)

Alternatives

Instead of having students use stopwatches, you may opt to be the timekeeper for the **Science Notebook 13.6A Heartbeat** and **Science Notebook 13.6B Pulse Rates and Exercise** activities. If you keep time with the classroom clock, have students face away from the clock.

Safety

Students with asthma or heart conditions are advised not to participate in the exercise portion of **Science Notebook 13.6B Pulse Rates and Exercise**. Allow them to be the timers in their groups and then have them record and graph their partners' data.

Objective

Students will locate and record their own pulse rate and analyze how it changes with activity.

Content

Measuring the pulse rate can give very important information about the health of a person. The pulse rate taken during exercise or immediately after exercise can give information about the fitness level of an individual.

When a person is at rest, the heart has little trouble circulating enough blood to supply the body cells with all the oxygen needed. However, during exercise, muscle cells demand more oxygen. The heart responds by increasing the number of times it contracts per minute. Whether resting or active, the number of times the heart beats is called *the heart rate* or *pulse rate*. An increased pulse rate circulates oxygenated blood faster, answering the demands of the muscles. After exercise, the need for extra oxygen decreases and the heart rate decreases accordingly. The time it takes for the heart rate to return to the resting rate is called *the recovery time*. The recovery time is related to cardiovascular fitness—healthy hearts have a shorter recovery time.

Normal pulse rates for children ages 6–15 are between 70–100 beats per minute. Resting heart rates that are consistently higher or lower than the normal range may indicate a problem. A person with a very firm, bounding (as in leaping) pulse that lasts longer than a few minutes or an irregular heart rate should be examined by a health-care provider.

Introduction

Ask students to imagine riding a bike along a flat road. Ask if they would have to pedal to make the bike go forward. (**Yes, but only gently.**) Now ask them to imagine riding up a hill. What they would have to do to the pedals? (**Push on them harder.**) Why would they have to do that? (**Going up a hill requires more power.**) Now have them imagine riding down the other side of the hill. Would they have to pedal? (**No, the bike is already going fast.**) Ask what would happen when they reach a flat spot again. (**The bike will begin to slow, and they will have to pedal in order to keep it going.**) Explain that, likewise, the heart speeds up to meet the requirements of the body, and it then slows down when the need has passed. Strenuous activity causes an increase in the amount of oxygen necessary for the cells to function properly. This need for more oxygen creates an increase in the heart rate. When the body returns to normal activity, the demand for more oxygen is reduced, thereby decreasing the heart rate.

Ask students to list ways by which they could determine how fast their heart is beating. (**Possible answer: hold my hand over my heart and count the number of beats**) Remind them that every time the heart contracts, it forces a wave of blood into the arteries and that the wave can be felt as a pulse. Explain that students will learn an easy way to determine how fast their heart is beating.

Directed Instruction

Science Notebook 13.6A Heartbeat

Read the directions aloud. Permit students to practice finding their radial and carotid pulse rates by using the illustrations to help them locate their pulses. Locate the radial pulse rate just below the thumb, on the wrist. Find the carotid pulse rate just below the jaw, about halfway between the chin and the ear. Have students move their fingers slowly until they feel the pulse.

After they have found their pulse, pair students and give each group a stopwatch. Have one student be the timer while the other student takes his or her own pulse rate. The timer will time for 15 seconds. The other student will count how many times his or her heart beats. Remind them they might feel two beats very closely together, feeling something like *lub-dub*. This is the sensation of the valves snapping shut when the heart contracts. It is considered one beat rather than two. Students should write down the number of beats and then multiply it by four to calculate their pulse rates per minute. Do not collect the notebook pages until all Science Notebook pages in this lesson are completed.

Science Notebook 13.6B Pulse Rates and Exercise

Have students remain with their partners. Have them write down their carotid pulse rates (per minute) from **Science Notebook 13.6A Heartbeat** in the *Resting* portion of the chart. Then ask them to follow Step 2 and to record the rate in the *After Exercise* box. Instruct students who have been running to sit down and rest while their partners time them for one minute. Have them take their pulse again immediately. Students who have difficulty finding their pulse might want to keep their fingers on the carotid so they do not lose their place. Have students write the pulse rate in the *1 Minute Recovery* box. Allow students to continue resting for three minutes. Then have them take their pulse rates again and record them. Direct students to proceed with Step 5. Instruct students to complete Exercises 1–2.

Science Notebook 13.6C Graphing Pulse Rates

Distribute colored pencils. Instruct students to transfer the data from their charts to the bar graph. Have them color each bar with a different color. Have students compare their graphed results with three other students. Instruct them to complete Exercises 1–2.

Science Notebook 13.6D Putting It All Together

Read the introduction aloud and instruct students to complete the exercises. Collect all Science Notebook 13.6A-D pages for assessment.

Lesson Review

How does exercise affect the heart rate? (**Exercise makes the heart beat faster.**) Does the heart rate stay at an accelerated rate after resting for a few minutes? (**No, it eventually returns to a normal heart rate.**) Why does the heart beat faster during exercise? (**The muscle cells need more oxygen, so the heart pumps faster to keep up with the demand.**) What are you listening to when you hear your heart beat? (**the sound of the valves closing**)

Challenge Questions

What kind of graph might you use to plot your pulse rate every minute during 10 minutes of exercise? Because a continuous change over time must be shown, a line or bar graph could be used.

Misconceptions

Children may think it is unhealthy to make the heart beat fast. Some may think that the harder the heart is worked, the weaker it becomes. On the contrary, getting regular exercise to increase the heart rate is very healthy for the heart as well as the rest of the cardiovascular system. The heart is a muscle. Just as an athlete lifts weights to strengthen his or her muscles, the heart must be exercised to remain strong. When the heart is strong, so is the blood flow through the blood vessels. Fats, cholesterol, and salt will bog down the heart and blood vessels, making them weak. Exercise is the only way to strengthen the heart. The more you do, the more you can do!

Notes:

Science Notebook Answer Key: Chapter 13

13.6A Notebook Heartbeat

Each time your heart contracts, it pumps blood into your arteries. But the heart does not pump smoothly, as constantly running water does. Instead, it pumps blood in a wave, or burst, then relaxes, then pumps another wave, then relaxes. Because of this pumping, the blood does not flow through your arteries smoothly either. The blood flows in waves that you can feel as a pulse. You can feel your pulse where a large artery crosses a bone. Two of the most common places to feel your pulse are on your wrist and on your neck. Look at the pictures below to help you place your fingers in the right positions.

Radial Pulse

Carotid Pulse

1. After you have found your radial and carotid pulses, pair up with a partner. One person will be the timer, while the other counts his or her own pulse. Then switch places.

2. Using a stopwatch, the timer will time 15 seconds. Say, "Start," when you start the time and, "Stop," when you stop the time.

3. When the timer says, "Start," begin counting your radial pulse. You may feel two beats occurring closely together. These two beats only count as one beat. Count the beats until the timer says, "Stop."

4. Record the number of beats. Multiply by 4 and write your answer. This is your pulse rate for one minute. Answers will vary. Normal range is about 70–100 beats per minute.

Radial Pulse _____ x 4 = _____

5. Repeat Steps 1–4 for your carotid pulse and record the number of beats. Answers will vary. Normal range is about 70–100 beats per minute.

Carotid Pulse _____ x 4 = _____

13.6B Notebook Pulse Rates and Exercise

Question: How will exercise affect your pulse rate?

Hypothesize: _____

Test It:

1. Record your carotid pulse rate from **Science Notebook 13.6A Heartbeat** in the Resting portion of the chart below.
2. Run in place for one minute while your partner times you. Stop immediately and take your pulse for one minute. Record the number on the chart.
3. Sit down right away and have your partner time you as you rest for one minute. After resting for one minute, immediately take your pulse again. Record the number on the chart.
4. Have your partner time you after you rest for three more minutes. Immediately take your pulse for one minute and record it on the chart.
5. Switch places with your partner and repeat Steps 1–4. Answer Exercises 1–2. Answers will vary.

Resting	_____ **beats per minute**
After Exercise	_____ **beats per minute**
1 Minute Recovery	_____ **beats per minute**
3+ Minutes Recovery	_____ **beats per minute**

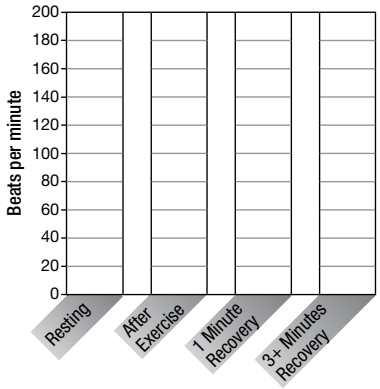
Analyze and Conclude:

1. Did your pulse increase or decrease after exercise? Why? Normally a person's pulse rate will increase after exercise because the cells require more oxygen, so the heart has to pump faster to meet the need.

2. Did your pulse rate increase or decrease after resting for one minute? After three minutes? Why? Normally a person's pulse rate will decrease slightly after the first minute and almost return to the resting pulse rate after three or more minutes. The muscle cells are not working as hard and do not need the higher amount of oxygen.

13.6C Notebook Graphing Pulse Rates

Use the data you collected to fill in the bar graph. Color in each bar with a different color. Answers will vary. Check answers on graph with data recorded on Science Notebook 13.6B.



1. Compare your graphed results with three other classmates. Write down their names. Answers will vary.

2. Did their pulse rates increase or decrease like yours did? Explain.

Although each person's pulse increased and decreased at different rates, generally each person's pulse rate should have increased after exercise and then decreased after resting.

13.6D Notebook Putting It All Together

In order to work properly, muscle cells, like all cells, must have enough oxygen. During exercise, the muscle cells demand even more oxygen than usual.

Complete the exercises.

1. How do your muscle cells get their oxygen?

The blood transports oxygen to my muscle cells.

2. How does the heart help the muscle cells get oxygen?

The heart pumps oxygen-rich blood to the muscle cells.

3. Why does your pulse rate increase when you exercise?

During exercise, my muscle cells need more oxygen. The heart beats faster to supply more oxygen to the muscle cells.

4. How long after exercise did it take for your pulse rate to return to the resting rate?

Answers will vary. Usually it takes three or more minutes.

5. Athletes who train often have very short recovery periods. How do you think you could shorten your recovery period?

By exercising more, I can decrease my recovery rate.

6. What conclusion can you draw about the relationship between pulse rate and physical activity?

Physical activity increases the heart rate. The faster the activity, the faster the the pulse rate. Regular exercise will help reduce recovery periods.